Accretion in High Magnetic Field Astrophysical Environments

M.T. Wolff (NRL), R.E. Rothschild (UCSD), P.A. Becker (GMU), and C.A. Wilson-Hodge (MSFC)

Accretion in Astrophysical Systems Remains a Major Research Challenge

Accretion is a major component in a vast range of astrophysical environments, from planet and solar system formation, to newly forming stars, including tidal disruption events, cataclysmic variables, mass exchange onto neutron stars and black holes in binary systems, all the way up to accretion onto the supermassive black holes that power active galaxies. Accretion is the beginning of processes that lead to jets and wind outflows from a wide range of systems. Understanding accretion in astrophysical systems remains an area of very important research in high-energy astrophysics and presents both theoretical and observational challenges over the next 30 years.

Need for Theoretical Calculations

Accretion ultimately consists of fluids under the influence of the gravitational field of the accreter, whether a newly forming planet or star, or a compact object such as a neutron star or black hole. Accretion simulations onto compact objects are sorely lacking, because of the difficulty of including all relevant physics. Such calculations must ultimately include multi-dimensional descriptions of plasma flows and radiative transfer in the magnetic environment around the possibly strongly gravitational central object. Large-scale theoretical calculations that include multi-dimensional magnetohydrodynamics and radiative transfer must generate real outputs of spectral and temporal characteristics including predictions regarding polarization of the emerging radiation that can be tested observationally. Magnetic fields can affect the accretion physics both in how the plasmas heat and cool themselves and how the plasma arranges itself into coherent flows such as magnetic funnels onto polar caps and magnetic dissipation and instabilities in accretion disks. What is the physical process that generates the jet close to the compact object and how are the jets collimated and accelerated to close to the speed of light? Finally, high energy density laboratory plasma physics is beginning to impinge on astrophysical parameter spaces and over the next 30 years could provide important constraints on the physics essential to building astrophysical models of magnetized plasmas.

Need for New Observing Missions

A mission with new instruments meeting the challenge of observing magnetic accreting systems needs energy coverage from 1 to 100 keV to probe the Comptonized continua in black hole and neutron star systems, as well as to study the cyclotron lines observed in accreting X-ray pulsars. A new X-ray instrument will require collecting areas significantly larger than RXTE/PCA with microsecond time resolution to pursue pulse phase resolved studies of accreting magnetic systems possibly below millisecond time scales. Larger effective areas and high time resolution allow the study of low and high frequency QPOs in accretion disks around neutron stars and the low significance QPOs predicted from the relativistic accretion disks around black holes. A new mission should have spectral resolving power near $\Delta E/E \sim 0.01$ or better to study general relativistic Fe-line formation in black hole systems and resolving cyclotron lines from accreting X-ray pulsars. Observing plans must be flexible and able to accommodate transient sources and multi-wavelength observing. Finally, a new X-ray mission must have an all-sky monitoring capability that allows rapid detection and response to transient outbursts.